U.S. Fish & Wildlife Service

Draft Recovery Plan for the Newcomb's Snail

(Erinna newcombi)

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DRAFT RECOVERY PLAN

for the

NEWCOMB'S SNAIL

(*Erinna newcombi*)

February 2004

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: XXXXXXXXXXXXXXXXX
Regional Director, Region 1
U.S. Fish and Wildlife Service

Date: XXXXXXXXXXXXXXXXX

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- http://pacific.fws.gov/ecoservices/endangered/recovery/default.htm
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EXECUTIVE SUMMARY

Current Species Status: Newcomb's snail (*Erinna newcombi*) is listed as a threatened species (65 FR 4162). The range of this small freshwater aquatic snail is limited to 10 very small stream and spring sites located in 6 watersheds in the mountainous interior of the Hawaiian island of Kaua`i. The historical range of the Newcomb's snail includes at least four additional watersheds where the snail is thought to have become extirpated. Total population size is estimated to be approximately 6,000 to 7,000 individuals, with the majority of individuals restricted to 2 of the 10 sites.

Habitat Requirements and Limiting Factors: Newcomb's snail is restricted to cool, clean, moderate- to fast-flowing water in streams and springs located at mid-elevations in valleys on the island of Kaua`i. Currently, the known distribution is limited to 10 small sites of approximately 2 to 30 square meters each (21.5 - 323 square feet). Suitable habitat appears to be limited primarily to areas exposed to channel scour brought about by periodic high-flow events. However, the island-wide distribution of Newcomb's snail prior to human-caused alteration of surface and groundwater systems was probably limited by long-term water supply: these snails are only found in locations that appear to have hydrologic regimes that support perennial flow throughout even the most severe drought conditions. Introduced predators may be limiting factors that currently affect snail populations and are found throughout their range. These include the non-native predatory snail *Euglandina rosea*, two species of non-native marsh flies (*Sepedomerus macropus* and *Sepedon aenescens*) that prey on aquatic snails, and possibly other species.

Critical Habitat: On September 20, 2002, we (the U.S. Fish and Wildlife Service) designated critical habitat for the Newcomb's snail (67 FR 54025). The designation includes eight stream segments and associated tributaries, springs, seeps, and adjacent riparian areas totaling 1,812 hectares (4,479 acres), and including 19.76 kilometers (12.28 miles) of stream channel. Critical habitat for the Newcomb's snail includes the six stream locations that are known to be occupied, and two sites where snails were observed historically but are now thought to be extirpated.

Recovery Objective: The objective of the actions proposed by this recovery plan is to recover the Newcomb's snail to the point where delisting is appropriate.

Recovery Priority Number: The recovery priority number for the Newcomb=s snail is 7 on a scale of 1 to 18 (1 equals the highest priority), indicating that it is facing a moderate degree of threat, has a high recovery potential, is a monotypic genus (not a species or subspecies), and does not currently have a significant amount of conflict, although recovery requires resolution of conflicting priorities for natural water flows on the Island of Kaua`i.

Recovery Criteria: The criteria outlined in this recovery plan will provide for maintenance of the majority of the genetic diversity of the Newcomb's snail, and will provide assurance that a single catastrophic event will not reduce populations of Newcomb's snail to the point where they are no longer viable.

The species can be considered for delisting when:

1. Abundance and population variability have been quantified, and an appropriate number of populations are stable or increasing in size due to natural reproduction for a minimum of 5 consecutive years;

2. Populations are located in a minimum of eight separate watersheds that are geographically distributed throughout its range;

3. Minimum flows are established for stream reaches where populations of Newcomb's snails are located;

4. Non-native predators and competitors have been studied, their effects quantified, and appropriate control measures have been established; and

5. A post-delisting monitoring plan covering a minimum of eight watersheds has been completed and is ready for implementation.

Actions Needed:

1. Establish baseline population numbers;
2. Research the population biology and life history of the Newcomb's snail;
3. Analyze and prevent predation and other forms of negative interspecific interactions that may limit or reduce Newcomb's snail populations;
4. Assure adequate stream and spring flows to protect known and potential Newcomb's snail habitat;
5. Incorporate recovery of Newcomb's snail into other landscape planning and conservation efforts, such as preservation of the structure and function of upland forests that maintain and regulate surface run-off to streams and act as areas of infiltration for groundwater;
6. Use initial recovery efforts and research to periodically validate recovery objectives; and
7. Develop and implement a public outreach program for Newcomb's snail conservation.

Date of Recovery: Delisting could be initiated by 2017, if conservation measures produce positive responses at each population site.

Estimated Cost of Recovery Actions (initial 5 years): The estimated cost of recovering the Newcomb=s snail is $2,529,000 through 2017 (see Implementation Schedule).

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I. INTRODUCTION

A. The Hawaiian Islands and Kaua`i

The Hawaiian archipelago consists of eight main islands and the numerous shoals and atolls of the northwestern Hawaiian Islands. Ongoing erosion has formed steep-walled valleys with well-developed soils and stream systems throughout the chain. Hawai`i Island is geologically the youngest of the main islands and is characterized by gently sloping shield volcanoes and frequent, long-lasting eruptions. Volcanoes on the other islands are dormant or extinct. Kaua`i, geologically the oldest and most northwesterly of the eight main islands, is characterized by deep valleys, high rainfall, abundant vegetation, and numerous streams and springs.

The island of Kaua`i is 1,430 square kilometers (552 square miles) in size, the fourth largest of the main Hawaiian Islands. Due to the age and climate of the island, Kaua`i is heavily eroded, with numerous steep, water-carved valleys and gulches. The prevailing northeasterly trade winds are typically laden with moisture in the central Pacific latitudes where Kaua`i is located. Substantial precipitation is brought to the windward and interior portions of the island as a result of uplift and cooling of the warm, moist surface airmass as it flows over the steep topography of the island. The high elevation areas in the vicinity of the Alaka`i Plateau, such as Mt. Wai`ale`ale (1,569 meters, 5,248 feet), are among the rainiest places on earth, receiving an average of 11.3 meters (444 inches) of precipitation annually (Juvik and Juvik 1998). This large volume of rainwater flows to perennial and intermittent streams and wetlands, and infiltrates into the island's aquifers. The west and southwest coastal areas of the island lie in the rain shadow of the Alaka`i Plateau and interior uplands, and these areas receive considerably less rain.

Kaua`i has at least 61 streams that are considered perennial and a similarly large number of intermittent streams (Hawai`i Stream Assessment 1990). The Hanalei River, for example, is 27 kilometers (17 miles) in length and is the largest stream system in the State by volume, with a long-term mean discharge of 6.5 cubic meters per second (216 cubic feet per second; 34 year average from 1964 to

1997). The headwaters of the Hanalei River are near the summit of Mt. Wai`ale`ale and the river flows towards Hanalei Bay on the island's north shore.

The basalts that form the bulk of the main Hawaiian Islands are porous and permeable, which facilitates infiltration and storage of groundwater. A large body of groundwater exists within these porous basalts at lower elevations throughout the island. In addition to this basal groundwater layer, smaller, perched groundwater systems form at higher elevations, contained by dense geologic features of low permeability. Many physical and biological characteristics of streams, such as channel function, are formed and maintained through the action of relatively frequent high-flow events. However, some low-flow characteristics are equally important, especially in the maintenance and distribution of aquatic life during periods of drought. Because groundwater reserves are extensive in some parts of the interior of Kaua`i, streams, springs and rock seeps (rheocrenes) fed by basal groundwater exhibit highly permanent, stable flows (Izuka and Gingerich 1998). As a result, the aquatic communities in these areas have persisted despite occasional severe drought, over long periods of geologic time.

Human-caused modifications to surface and groundwater systems on Kaua`i and throughout Hawai`i have profoundly altered natural hydrologic regimes. Extensive and complex irrigation systems, built to support the cultivation of sugarcane over a century ago, transfer large volumes of water out of natural watercourses and into extensive systems of ditches, tunnels, flumes, reservoirs, and ultimately, to fields. Historically, streamwater diversion structures were built to be highly efficient in their ability to entrain water. These dams divert all flowing stream water at moderate to low flows, leaving the stream channel below the dam completely dry. At least one third of all Kaua`i's streams are significantly dewatered for agricultural and industrial water supplies (Hawai`i Stream Assessment 1990). In 1994, a total of 849.60 million liters (224.17 million gallons) per day was used island-wide for irrigation, and 355.20 million liters (93.72 million gallons) per day was used for generation of hydroelectric power (Wilcox 1996).

B. Species Description and Taxonomy

Four species of Lymnaeidae snails are native to Hawai`i (Morrison 1968, Hubendick 1952). Three of these species are found on two or more of the eight main islands. The fourth species, Newcomb's snail, is restricted to the island of Kaua`i. Newcomb's snail is unique among the Hawaiian lymnaeids in that the shell spire typically associated with lymnaeids has been substantially reduced. The result is a smooth, black shell formed by a single, oval whorl, 6 millimeters (0.25 inch) long and 3 millimeters (0.12 inch) wide. A similar shell shape is found in a Japanese lymnaeid (Burch 1968), but a study of chromosome numbers shows that Newcomb's snail has evolutionary ties to the rest of the Hawaiian lymnaeids, all of which are derived from North American ancestors (Patterson and Burch 1978). This parallel evolution of similar shell morphology in Japan and Hawai`i from two distinct lineages of lymnaeid snails is of particular scientific interest.

At the present time, there is no generally accepted nomenclature for the genera of Hawaiian lymnaeids, although each of these snail species, including Newcomb's snail, is recognized as a well-defined species. Newcomb's snail was originally described as *Erinna newcombi* in 1855 by Henry & Arthur Adams (see Hubendick 1952). Hubendick (1952) did not feel that the distinctive shell form (described above) and reduced structures of the nervous system of Newcomb's snail warranted a monotypic genus. In fact, Hubendick included all Hawaiian lymnaeids in the genus *Lymnaea*. Morrison (1968) contradicted Hubendick, and argued that the distinctive shell characters of Newcomb's snail supported the generic name *Erinna*. Burch (1968), Patterson and Burch (1978), Taylor (1988), and Cowie *et al*. (1995) all followed Morrison and referred to Newcomb's snail as *Erinna newcombi*. This is the currently accepted scientific name for Newcomb's snail.

C. Life History and Ecology

Newcomb's snail is an obligate freshwater species. While the details of its ecology are not well known, Newcomb's snail probably has a life history similar to other members of the family. These snails generally feed on algae and vegetation growing on submerged rocks. Eggs are attached to submerged rocks

or vegetation and there are no widely dispersing larval stages; the entire life cycle is tied to the stream system in which the adults live (Baker 1911). Nothing is known about the biological or environmental factors that affect population size in Newcomb's snails. Important factors may include annual, multi-year, or decadal changes in stream flows; severe-weather, high-flow, channel-scouring events; and periods of severe or prolonged drought. Dispersal of snails in both upstream and downstream directions within a stream system probably plays an important function in gene flow and in colonizing or recolonizing suitable habitat, particularly microhabitat that is protected from channel scour. Dispersal of Newcomb's snail between stream systems is likely very infrequent due to their obligate freshwater habitat requirements, and historic dispersal probably relied on long-term erosional events that captured adjacent stream systems. It should be noted that this life history differs greatly from the freshwater Hawaiian neritid snails (*Neritina granosa*, *Neritina vespertina*), which have marine larvae that colonize streams following a period of oceanic dispersal (Kinzie 1990). It is probable that the planktonic larvae of these neritid snails can disperse across the oceanic expanses that separate the main Hawaiian Islands and colonize streams on any or all of these islands. This dispersal capacity is not available to Newcomb's snail.

Based on past and recent field observations, the specific habitat requirements of Newcomb's snail include fast-flowing perennial streams and associated springs, seeps, and vertical-to-overhanging waterfalls (Stephen Miller, U.S. Fish and Wildlife Service *in litt*. 1994a; Polhemus *et al*. 1992; Burch 1968; and Hubendick 1952). Surveys of main stream channels of many of the perennial streams of Kaua`i indicate that Newcomb's snail is only found in areas protected from scouring high flows within main stream channels (Michael Kido, University of Hawai`i, *in litt*. 1994). The limited occurrence of this snail in main stream channels is likely due to periodic channel scouring by sediment, rocks, and boulders that are moved downstream during runoff events due to frequent heavy rains. Consequently, suitable habitat is generally associated with overhanging waterfalls located in the main channel of perennial streams supported by stable groundwater input, or with the more protected, small, spring-fed tributaries. Another common element among sites harboring snail populations is that the water source appears to be consistent and permanent, even during severe drought.

Newcomb's snails are limited to a relatively narrow zone of mid-elevation sites. Populations of Newcomb's snail are found at an average elevation of 306 meters (1,005 feet), and range between 196 meters and 396 meters (643 feet to 1,299 feet).

D. Distribution and Population Status

The collection of the U.S. Exploring Expedition of 1838-1842 obtained specimens of Newcomb's snails collected at "Hanapepe Falls," presumably one of several waterfalls located in the lower Hanapepe watershed of southeast Kaua'i (Morrison 1968). The individuals from this early collection were used as the type specimens from which the species was described. No recent surveys for Newcomb's snails have been undertaken in the Hanapepe watershed or neighboring watersheds. However, due to the drastic reductions in stream flows caused by irrigation withdrawals in that region of the island, we suspect that snail populations in these streams were extirpated over a hundred years ago.

Five populations of Newcomb's snail were known to exist more recently. Until about 1925, populations were known from small sites located in Kalalau Stream, Hanakoa Stream, Hanakapi`ai Stream, Wainiha River, and the Waipahe`e tributary of Kealia Stream. Three of these populations (Hanakoa Stream, Hanakapi`ai Stream, Wainiha River) are now thought to be extirpated. Of the two remaining pre-1925 populations, one (the Waipahe`e tributary of Kealia Stream) is small and the other (Kalalau Stream) is relatively large. Since about 1993, surveys at approximately 50 sites located along numerous streams and their associated tributaries and springs on Kaua'i have located four previously unknown populations of Newcomb's snail (M. Kido, *in litt*. 1994). These recently discovered populations are located in Lumaha`i River, the Hanalei River, Makaleha Stream (a tributary to Kapa`a Stream), and the North Fork Wailua River. Recently, two individual snails were reported from a single site in Limahuli Stream in the Hanalei District of Kauai's north shore (M. Kido, *in litt*. 2001). However, if a viable population of Newcomb's snail exists in the Limahuli watershed, it has not been located, and therefore Limahuli Stream is not considered to have a "population" of Newcomb's snails.

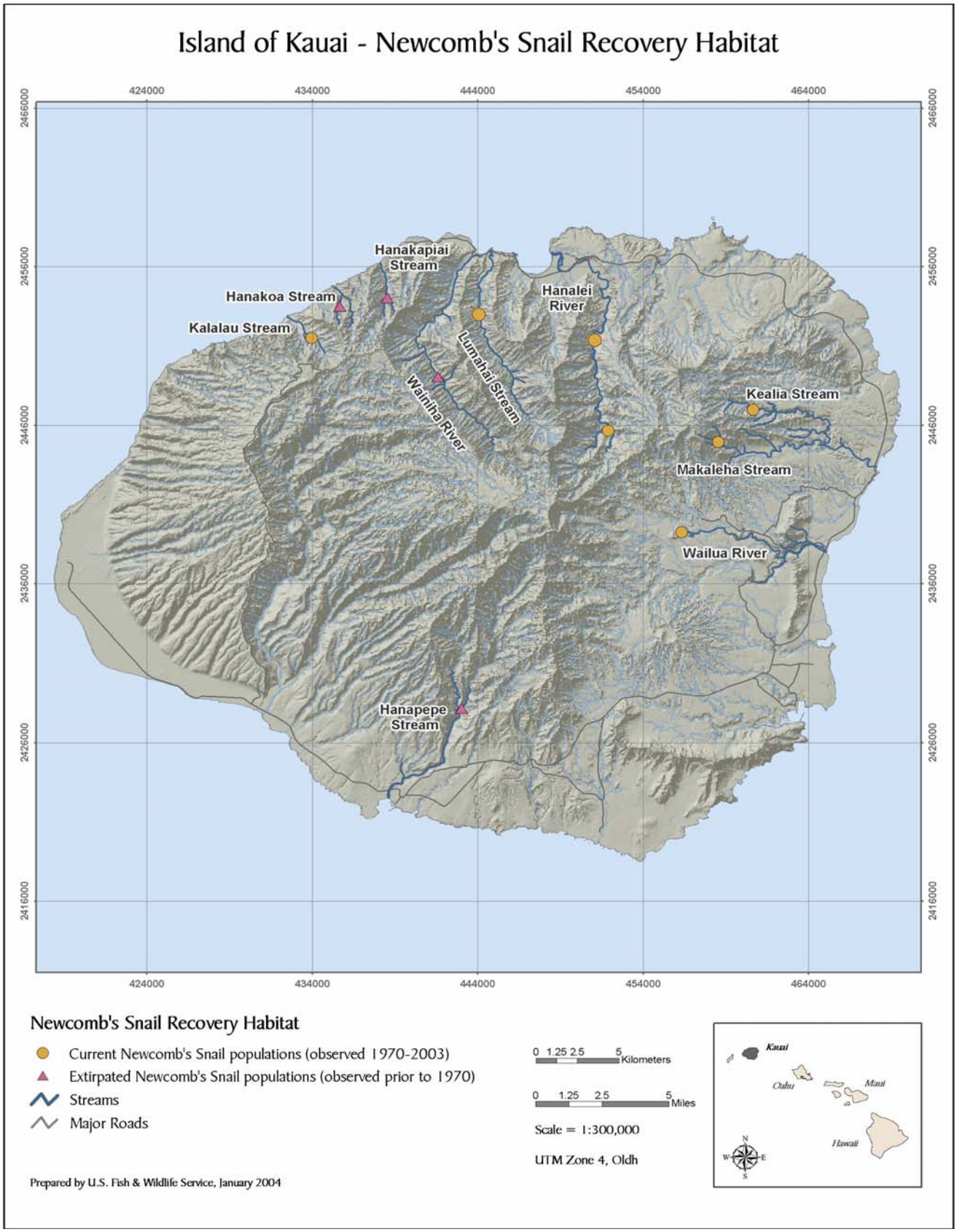
As a result of recent survey work, the known range of Newcomb's snail is limited to very small sites found in a total of six watersheds in north- and east-facing drainages on Kaua`i (Figure 1). They are: Kalalau Stream, Lumaha`i River, Hanalei River (four subpopulations), Waipahe`e tributary of Kealia Stream, Makaleha Stream (two subpopulations), and the North Fork Wailua River. The term "subpopulation" refers to discreet groups of individuals found within a single watershed. No historical information is available on the population sizes of Newcomb's snail. However, recent reports indicate that the Kalalau Stream and Lumaha`i River populations of Newcomb's snail are larger in comparison to the other four.

Kalalau Stream

The Kalalau Stream population is found in the northeastern fork of Kalalau Stream on two permanent waterfalls and in the stream reach between the waterfalls. The high density of individuals in this population may be a result of its apparently undisturbed natural condition. The estimated maximum density at the base of the upper waterfall, including the area behind the falling water, is approximately 800 snails/square meter (75 snails/square foot) (S. Miller *in litt*. 1994b). The total area occupied by these snails could not be accurately evaluated due to the extreme vertical orientation of the waterfall. Habitat used by these snails may be limited to the lower section of the waterfall that receives a high amount of spray from the falling water. Whether this is an indication of a preference for highly oxygenated water is not clear. Some snails exist in groundwater emanating directly out of the rock, and no data exists on how well this water is oxygenated.

Lumaha`i River

No information on specific size or area is currently available for the population of Newcomb's snail in the Lumaha`i River, although this population was reported to be "large" (M. Kido *in litt*. 1995). This population has only been visited once, on the occasion of its discovery. The Hawai`i Department of Land and Natural Resources Division of Aquatic Resources biologist that found the population did not undertake a quantitative survey of snail numbers at this location.


Island of Kauai - Newcomb's Snail Recovery Habitat
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Hanakapiai Stream
Hanakoa Stream
Kalalau Stream
Hanalei River
Lumahai Stream
Wainiha River
Kealia Stream
Makaleha Stream
Wailua River
Hanapepe Stream
Newcomb's Snail Recovery Habitat
Current Newcomb's Snail populations (observed 1970-2003)
Extirpated Newcomb's Snail populations (observed prior to 1970)
Streams
Major Roads
0 1.25 2.5 5 Kilometers
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Hanalei River

The population of Newcomb's snail in the Hanalei River is divided into four subpopulations in the upper reach (M. Kido *in litt*. 1994, 1995). One subpopulation has approximately 10 to 20 snails/square meter (1 to 2 snails/square foot) and occupies 2 to 3 square meters (21 to 32 square feet) (M. Kido *in litt*. 1994). A second subpopulation supports approximately 25 snails total. The two remaining subpopulations in the Hanalei River are reported to be "small" with very few snails (M. Kido *in litt*. 1995).

Waipahe`e Stream of Kealia Stream

The population in the Waipahe`e tributary of Kealia Stream is estimated to cover 5 to 10 square meters (53 to 106 square feet) with a density of approximately 50 to 80 snails/square meter (4 to 8 snails/square foot) (A. Asquith, U.S. Fish and Wildlife Service *in litt*. 1994).

Makaleha Stream

The population in Makaleha Stream is divided into two subpopulations. The subpopulation at the waterfall that forms the head of the main channel of Makaleha Stream is estimated at 30 snails/square meter (2 to 3 snails/square foot) distributed over 2 to 3 square meters (21 to 32 square feet) (M. Kido *in litt*. 1994). This is considerably smaller than the population in Kalalau Stream described above. The reasons for the small subpopulation at Mkaleha Stream is not known with certainty, but may be due to the presence of non-native predators, and "biological control" species introduced to feed on non-native species, both of which may feed on lymnaeid snails. The subpopulation that occupies Makaleha Springs (which forms a series of very small, short tributaries to Makaleha Stream) covers approximately 20 to 30 square meters (212 to 318 square feet) (S. Miller *in litt*. 1994b). Snail densities at this site are difficult to estimate, but may be as high as 20 to 30 snails/square meter (1 to 3 snails/square foot) (S. Miller *in litt*. 1994a).

North Fork Wailua River

The population found in the upper reaches of the North Fork of the Wailua River, just upstream of a concrete agricultural water diversion intake, was made up of a few scattered individuals during surveys in 1996 and 1997 (M. Kido and Don

Heacock, Hawai`i Department of Land and Natural Resources, Division of Aquatic Resources, pers. com. 2001).

Based on these data, by mid-1995, we estimated that the 6 known populations of Newcomb's snail had a total of approximately 6,000 to 7,000 individuals. The great majority of these snails, perhaps over 90 percent, were located in the two populations at Kalalau and Lumaha`i. The terrain where Newcomb's snail populations are found is remote and extremely rugged. Three of the six populations can only be visited using helicopter transport, although the Kalalau Stream population potentially could be accessed in summer months with boat support and strenuous hiking. No Newcomb's snail surveys have been undertaken since 1995, and any changes to the population since that time have not been documented.

It is important to note that the total area inhabited by Newcomb's snails at any one location is remarkably small, from just 2 square meters (22 square feet; Makaleha waterfall, Hanalei subpopulations) to a maximum of 30 square meters (323 square feet; Makaleha Springs subpopulation). Microhabitat characteristics that limit suitable habitat are not known. Because known populations are limited to such small areas, they are highly vulnerable to eradication by unpredictable catastrophic events. Hurricane and tropical storm-caused flooding, catastrophic landslides, drought, infestation by introduced invasive species, and other localized phenomena that occur unpredictably could eradicate Newcomb's snail habitat across significant portions of the island. Recent examples of such recurring natural events include Hurricane Iniki (a Category IV hurricane that devastated Kaua`i on September 11, 1992), Hurricane Iwa (November 23, 1982), and the huge upper Olokele Valley landslide of October 31, 1981. Each of these events greatly impacted or entirely eliminated large areas of potential Newcomb's snail habitat that had never been surveyed to locate snail populations. Any recovery planning effort must take the island-wide distribution of Newcomb's snails into account to ensure maintenance of separate populations in watersheds that are distributed geographically throughout the island.

E. Reason for Decline and Current Threats

Disease and Predation

Predation by the non-native rosy glandina snail (*Euglandina rosea*) is a serious threat to the survival of Newcomb's snail. This predatory snail was introduced into Hawai`i in 1955 (Funasaki *et al*. 1988), and has established populations throughout the main islands. The rosy glandina feeds on snails and slugs, and field studies have established that it will readily feed on native snails found in Hawai`i (Hadfield *et al*. 1993). Furthermore, Kinzie (1992) demonstrated that the rosy glandina snail exhibits remarkable hunting behaviors that lead to capture and predation of submerged prey. Although it is terrestrial, the rosy glandina will fully immerse itself under water to locate and feed on aquatic molluscs such as Newcomb's snail. The rosy glandina has been observed on the wet, algae-covered rocks of the Makaleha Springs stream in close proximity to individuals of Newcomb's snail (S. Miller *in litt*. 1994a), and is believed to prey on them. The rosy glandina snail has caused the extinction of many populations and species of native snails throughout the Pacific Islands (Hadfield *et al*. 1993, Miller 1993, Hopper and Smith 1992, Murray *et al*. 1988, Tillier and Clarke 1983), and represents a significant threat to the survival of Newcomb's snail.

Predation on the eggs and adults of native Hawaiian lymnaeid snails by two non-native species of sciomyzid flies represents a significant threat to the survival of Newcomb's snail. Two species of marsh flies (*Sepedomerus macropus* and *Sepedon aenescens*) that feed on lymnaeid snails (Davis 1960) were introduced into Hawai`i in 1958 and 1966, respectively. These predatory flies were intended to act as biological control agents for the non-native lymnaeid snail, *Fossaria viridis* (Funasaki *et al*. 1988). As discussed in Morrison (1968), another non-native lymnaeid snail, *Galba viridis*, was misidentified as *Fossaria ollula* by earlier workers (Alicata 1938, Alicata and Swanson 1937). This species was also targeted for biological control because it is an intermediate host of the cattle liver fluke (*Fasciola gigantica*). The non-native lymnaeid snails and the two biological control flies occur on Kaua'i as well as on other islands in Hawai`i (Funasaki *et al*. 1988, Davis and Chong 1969, Davis 1960, Hubendick 1952). One of the marsh fly species has been observed at Hanakoa Stream where

Newcomb's snail was historically recorded but is no longer present (S. Miller *in litt*. 1994b). A marsh fly was observed near the waterfall of Manoa Stream that had many dead lymnaeids in the waterfall plunge pool (S. Miller *in litt*. 1994b). Another marsh fly was observed along a small unnamed tributary on the middle reach of the Lumaha'i River, close to the Newcomb's snail population in that watershed (G. Smith pers. obs., Nov 2000). These biological control species represent a significant threat to Newcomb's snail and other native lymnaeid snails.

Populations of Newcomb's snail are potentially threatened by several introduced, predatory aquatic species, including the green swordtail fish (*Xyphophorus helleri*), the American bullfrog (*Rana catesbiana*), and the wrinkled frog (*Rana rugosa*). Over 50 species of non-native aquatic organisms have been naturalized into Hawaiian freshwater habitats, including at least 50 species of fish (Yamamoto and Tagawa 2000). Some of the earliest introductions are the most widespread. In 1867, the American bullfrog was introduced, and in 1896, the wrinkled frog was first recorded (State of Hawai`i, Job Progress Report, 1995). In 1905, two fish species, the mosquito fish (*Gambusia affinis*) and the sailfin molly (*Poecilia latipinna*), were widely introduced for biological control of mosquitoes (Van Dine 1907). In 1922, three additional fish species were established for mosquito control: the green swordtail, the moonfish (*Xiphophorus maculatus*), and the guppy (*Poecilia reticulata*). All potentially predate the Newcomb's snail.

Hydrologic Changes

Newcomb's snails face a continued threat from human-caused changes to the hydrologic landscape of Kaua`i. The first collection and description of the species by western naturalists was made prior to the severe degradation of natural aquatic environments. The collection of the 1838-1842 U.S. Exploring Expedition contains Newcomb's snails collected at "Hanapepe Falls," apparently one of the waterfalls located in the middle or lower Hanapepe watershed (Morrison 1968). Because of irrigation water withdrawals, this stream now has reaches below diversion structures that are entirely dewatered and are dry much of the time. The Hanapepe watershed is located in the southwest quadrant of the island where industrial plantation-style agriculture is extensive and continues to divert and pump significant volumes of water out of both surface waterbodies and

groundwater reserves. The watersheds in this part of the island are widely separated geographically from currently known Newcomb's snail populations in drainages located in the north and northeast part of the island. No recent information suggests the presence of Newcomb's snails in Hanapepe or other southwest Kaua`i watersheds, however these areas have not been surveyed for Newcomb's snails. Much of the land in this part of the island is privately owned, and to date little cooperation with natural resource agencies has occurred. Planning and management strategies for both State-owned and private lands emphasize continued or expanded large-scale agricultural operations that divert stream water.

The specific effects of surface water diversion or groundwater withdrawal on Newcomb's snail are not known. However, none of the six known snail populations are currently found below points of surface water diversion. In the case of the four Hanalei subpopulations, three are found in close proximity to, or below, sites that were part of a major stream diversion complex that is now abandoned and nonfunctional. These subpopulations were not reported prior to this diversion complex falling into disuse, so effects on snails, other than possibly reducing snail abundance below the level of detection, are not known. As recently as 1995 (prior to Newcomb's snail being listed as threatened), a major water diversion project was planned to capture flow from Makaleha Springs for domestic use. The project construction and operation would likely have eliminated the entire population of Newcomb's snail at Makaleha Springs. Despite this, the application process was pursued vigorously by the project proponents and cleared a number of State and local regulatory reviews. Ultimately, the State Commission on Water Resource Management denied the applicable permits on the basis of numerous unresolved environmental issues, including impacts to aquatic life.

Two of the six Newcomb's snail populations are on private lands, and the remaining four are located on State of Hawai`i lands. The total acreage of Federal land on Kaua`i is quite small, and no Newcomb's snails are known to occur on Federal land. As a result of listing Newcomb's snail as threatened, future water diversion projects that may affect known or suspected Newcomb's snail habitat will be subject to increased scrutiny by State water resource managers. There is no direct Federal regulatory oversight of the allocation of out-of-stream versus in-

stream water resources, so the cooperation of State water resource managers will play a critical role in planning for Newcomb's snail recovery.

F. Conservation Measures

Newcomb's snail was listed under the Endangered Species Act as threatened on January 26, 2000 (65 FR 4162). An endangered species is defined in section 23 of the Endangered Species Act as any species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is defined as any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

The Endangered Species Act provides several opportunities for the conservation of threatened and endangered wildlife and the ecosystems on which they depend. Listed species receive recognition and protection against take. The term "take" is defined as to harass, harm, shoot, wound, kill, trap, capture, or attempt to engage in any such conduct. "Harm" is further defined to include significant habitat modification or degradation that results in mortality or injury of wildlife by significantly impairing essential behavioral patterns such as breeding, feeding, or sheltering (50 CFR 17.3). Federal agencies must ensure that their actions do not jeopardize the continued existence of a listed species or adversely modify its designated critical habitat. The Endangered Species Act also prohibits possessing, selling, delivering, carrying, transporting, or shipping in interstate or foreign commerce any listed fish or wildlife species, except as permitted under provisions of section 10 of the Endangered Species Act.

Section 4(b) of the Endangered Species Act requires that we designate critical habitat for species that are listed as threatened or endangered. Critical habitat is a specific geographic area that is essential for the conservation of a threatened or endangered species and that may require special management and protection. Critical habitat may include an area that is not currently occupied by the species but that will be needed for its recovery. On August 20, 2002, we designated critical habitat for the Newcomb's snail (67 FR 54025). The designation includes eight stream segments and associated tributaries, springs, seeps, and adjacent riparian areas totaling 1,812 hectares (4,479 acres), and including 19.76 kilometers (12.28 miles) of stream channel. Critical habitat for

the Newcomb's snail includes the six stream locations that are known to be occupied and two sites where snails were observed historically but are now thought to be extirpated (see Table 1, p. 14).

When a species is listed as threatened or endangered under the Endangered Species Act, it is automatically added to the State of Hawai`i's list of protected species (Hawai`i Revised Statutes [HRS] Chapter 195D). Hawai`i State law prohibits take of threatened fauna and encourages conservation by State government agencies ("take" as defined by Hawai`i State law means to "harass, harm, pursue, wound, kill, trap, capture, collect... or attempt to engage in any such conduct"). Further, the State may enter into agreements with Federal agencies to administer and manage any area required for the conservation, management, enhancement, or protection of threatened or endangered species.

Newcomb's snail is the first freshwater organism found in Hawai`i to be listed in Federal and State law as threatened. The Hawai`i Department of Land and Natural Resources, Division of Aquatic Resources is building its capacity to undertake research and implement management directed towards conservation of rare and vulnerable aquatic species such as the Newcomb's snail. Interaction with our endangered species biologists will be an important element in assisting Division of Aquatic Resources management and staff with developing an institutional framework that will accomplish effective conservation for the Newcomb's snail. To date, no conservation measures have been implemented.

II. RECOVERY

A. Recovery Objective

The ultimate objective of the actions proposed in this recovery plan is to recover the Newcomb's snail to the point where delisting is appropriate. Delisting decisions include consideration of the snail's population trends, exposure to threats, life history characteristics, and protection of habitat, especially stream and spring flows. Because we only have limited knowledge of the life history of this species, including specific requirements for its short-term and long-term survival, research must be undertaken prior to consideration of delisting.

B. Recovery Criteria

The species can be considered for delisting when:

1. Abundance and population variability have been quantified, and an appropriate number of populations are stable or increasing in size due to natural reproduction for a minimum of 5 consecutive years;

2. Populations are located in a minimum of eight separate watersheds that are geographically distributed throughout its range;

3. Minimum flows are established for stream reaches where populations of Newcomb's snails are located;

4. Non-native predators and competitors have been studied, their effects quantified, and appropriate control measures have been established; and

5. A post-delisting monitoring plan covering a minimum of eight watersheds has been completed and is ready for implementation.

These criteria should maintain the genetic diversity of the Newcomb's snail, and ensure that a catastrophic event does not destroy all members of the species.

Recovery actions should focus on protecting the most significant Newcomb's snail populations first (see Table 1). "Tier 1" populations are designated based primarily on total number of snails and likelihood of habitat protection efforts being successful. "Tier 2" populations are designated based on wide geographic distribution and existence of extant populations. "Tier 3" populations are based on historical records that document the existence of suitable habitat, but lack of information concerning extant snail populations.

C. Recovery Strategy

The recovery of the Newcomb's snail will depend on several recovery actions:

1. Establishing baseline population numbers;
2. Researching the population biology and life history of the Newcomb's snail;
3. Analyzing and preventing predation and other forms of negative interspecific interactions that may limit or reduce Newcomb's snail populations;
4. Assuring adequate stream and spring flows to protect known and potential Newcomb's snail habitat;
5. Incorporating recovery of Newcomb's snail into other landscape planning and conservation efforts, such as preservation of the structure and function of upland forests that maintain and regulate surface run-off to streams and act as areas of infiltration for groundwater;
6. Using initial recovery efforts and research to periodically validate recovery objectives; and
7. Developing and implementing a public outreach program for Newcomb's snail conservation.

Table 1. Newcomb's Snail Populations and Priority Actions

Populations	Required Research	Recovery Actions
Tier 1 Populations:		
Kalalau Stream*	1) Population census 2) Characterize interactions with introduced species 3) Map location	1) Introduced species control
Lumaha`i Stream*	1) Population census 2) Characterize interactions with introduced species 3) Map location	1) Instream flow protection 2) Introduced species control
Tier 2 Populations:		
Hanalei River* (Four subpopulations)	1) Population census 2) Characterize interactions with introduced species 3) Map location	1) Instream flow protection 2) Introduced species control
Makaleha Stream* (Two subpopulations)	1) Population census 2) Characterize interactions with introduced species	1) Introduced species control
Waipahe`e Stream* of Kealia Stream	1) Population census 2) Characterize interactions with introduced species	1) Instream flow protection 2) Introduced species control
North Fork Wailua River*	1) Population census 2) Characterize interactions with introduced species	1) Instream flow protection 2) Introduced species control
Tier 3 Populations:		
Hanakoa Stream*	1) Confirm if snails extirpated 2) Assess threats at potential translocation sites	1) Translocation experiments
Wainiha River	1) Confirm if snails extirpated 2) Assess threats at potential translocation sites	1) Instream flow protection 2) Translocation experiments
Hanakapi`ai Stream*	1) Confirm if snails extirpated 2) Assess threats at potential translocation sites	1) Translocation experiments

*Designated as Critical Habitat

Research and Monitoring

Research on population characteristics and optimal habitat conditions for the Newcomb's snail will assist in the development of appropriate recovery actions, and will allow recovery criteria to be verified or refined. Recovery actions will be guided by monitoring protocols, and habitat restoration goals and techniques.

Research and monitoring are key activities that will lead to reaching the ultimate goal of delisting the Newcomb's snail. Because current information is so limited, even the most basic management actions cannot be undertaken with the certainty that such actions will benefit the species. The initial focus will be on developing and applying survey and monitoring techniques, and on collecting basic life history information. In particular, accurate population estimates throughout the known range of the snail are needed. In the earliest stages, this work should be undertaken so that all currently known populations of the snail are surveyed at a single point in time to provide an accurate estimate of the number of all snails that exist. Life history information, such as fecundity, should be investigated by documenting egg mass deposition. Microhabitat requirements should be documented by measuring substrate, flow velocity, and other fine-scale characteristics in stream and spring areas inhabited by Newcomb's snail. The resulting information on life history and habitat characteristics will be used to plan possible snail translocation activities and other recovery efforts.

Evaluation of the need for and likelihood of success of translocation efforts to establish (or re-establish) populations of Newcomb's snail should be undertaken. Sites located on Hanakoa Stream, Hankapi`ai Stream, and Wainiha River where Newcomb's snails were found in the years 1880-1925, but are now presumed extirpated, should be the first locations assessed for reintroduction. Microhabitat requirements appear to be severely limiting for the snail, and considerable research will have to be done to develop the expertise to undertake experimental translocations of this species. In addition to careful investigation into habitat suitability in watersheds considered for translocation experiments, an assessment of threats due to a variety of factors such as predation and severe weather events will be required at each site.

Predation

Assessments of threats should be accomplished through research and monitoring. In particular, populations of the carnivorous snail *Euglandina rosea* should be surveyed in areas adjacent to known populations of Newcomb's snail, and the potential threat posed by these introduced predators should be assessed. If predation by *Euglandina rosea* is a significant factor inhibiting the recovery of Newcomb's snail, appropriate control measures should be developed in concert with *Euglandina* control efforts elsewhere.

Stream and Spring Flows

Maintenance and protection in perpetuity of adequate water flows, at the stream and spring sites where Newcomb's snail populations are found, must be accomplished through coordination and cooperation with the agency ultimately responsible for regulating surface water and groundwater allocation: the Hawai`i Department of Land and Natural Resources, Commission on Water Resource Management (Water Commission). The Water Commission was created through Article XI, Section 7 of the 1978 State Constitution, and authorized by the State Water Code (Hawai`i Revised Statutes Chapter 174C). A variety of administrative rules (Hawai`i Administrative Rules Chapters 13-167 to 13-171) and related policy and planning documents guide the Water Commission in its mission as trustee of the State's surface and groundwater for the benefit of the people of the State of Hawai`i.

The Water Commission regulates the withdrawal of groundwater through a well construction and pump installation permit program, and a water use permit program. Alteration of instream flows is regulated through a permitting and water use allocation system that includes a variety of permits for diversion work and stream channel alteration, and petitions to amend existing interim instream flow standards. Diversion of surface water for use in agriculture, resort, and golf course development, and for domestic purposes, is often a contentious public policy issue, and Water Commission decision-making efforts can be lengthy. When the Water Commission is called upon to act in its capacity as a quasi-judicial body, such as in a contested case hearing, final decisions regarding water use allocation may take several years to resolve. Decision-making regarding

water rights that are brought to the courts for resolution may take much longer. For example, the landmark *McBryde Sugar Co. vs. Robinson* case, which grew out of a dispute over diversion of irrigation water from the Hanapepe River on Kaua`i, involved water rights and the public trust, and was adjudicated by the Hawai`i State Supreme Court for over 20 years, from the early 1950's until 1973 (Wilcox 1996).

State policies that establish management goals for water resources are sometimes contradictory within the various departments that have missions for water use and water conservation. The Water Commission has conflicting mandates to fully utilize water resources for agricultural and domestic uses, while simultaneously maintaining conservation of natural resources. Coordination with the Water Commission and other stakeholders regarding instream flow protection for conservation of Newcomb's snail habitat is critical to recovery of the species.

Cooperative Planning and Public Outreach

Restored habitat and populations require long-term protection from threats. Involvement of the public (especially major landowners) in recovery efforts, increased public awareness of the Newcomb's snail and its habitat, our participation in State and county watershed planning and conservation programs, and enforcement of applicable laws and regulations should help ensure the long-term protection of populations and habitats.

III. RECOVERY ACTION NARRATIVE

1. Conduct research and monitoring essential to the conservation of the species. Basic information about the population size, distribution, and variability is required for effective conservation of Newcomb's snail. Information gathered from population monitoring, surveys to locate possible undiscovered populations, and life history studies will aid in formulating recovery goals and management activities (refer to Table 1).

1.1. Surveys and monitoring. Develop standardized survey and monitoring protocols to determine Newcomb's snail distribution and abundance.

1.2. Implementation of monitoring program. Implement a population monitoring program to determine Newcomb's snail abundance and population variability. Survey all Newcomb's snail populations synoptically on a 1- to 2-year cycle to assess trends in population status.

1.3. Obtain basic life history information. Coincident with initiation of regular monitoring, basic life history characteristics should be described. These characteristics should include fecundity, egg loss/mortality, maximum size, and incidence and prevalence of observable disease or parasitism.

1.4. Survey potential and historical habitat. Significant areas of potential habitat have never been surveyed to locate undiscovered populations of Newcomb's snail, and at least one location of historically occupied habitat has not been resurveyed for Newcomb's snail for over 150 years. These areas should be visited and resurveyed as time and resources allow. The recently reported occurrence of two individual Newcomb's snails in Limahuli Stream should be investigated.

1.5. Initiate translocation program. Opportunities for reintroduction of Newcomb's snails to locations where they have

recently become extirpated should be undertaken once sufficient knowledge is obtained regarding habitat needs and reduction of threats, especially predation. Historically occupied sites at Hanakoa Stream, Hanakapi`ai Stream, and the Wainiha River should be considered first.

1.6. Validate recovery objectives.

1.6.1 Determine the number of populations and individuals needed for long-term recovery and survival. An evaluation of recovery actions and results using population viability analysis techniques or other methodology should be accomplished after approximately 5 years of implementing this plan. A population viability analysis could be conducted by utilizing population data obtained through the implementation of this recovery plan.

1.6.2 Revise delisting criteria as necessary. New information may be obtained that would require changes to recovery planning objectives defined in this recovery plan. If Newcomb's snail populations undergo an unforeseen increase or decrease, or if one or more populations become locally extirpated due to predation or natural disasters such as hurricanes, floods, landslides or other unforeseen events, revisions to recovery criteria must be initiated as appropriate.

2. Manage predation and interspecific interaction. Assess the threat of predation by introduced species and develop appropriate conservation measures to protect Newcomb's snail from excessive predation.

2.1. Predation by *Euglandina rosea*. Conduct surveys to estimate the threat of predation by *Euglandina rosea*. Surveys should focus on numbers and densities of *Euglandina* in habitat adjacent to sites where Newcomb's snails are known to occur.

2.2. Predation by *Sepedomerus macropus* and *Sepedon aenescens*. Conduct surveys to estimate the threat of predation by the marsh flies *Sepedomerus macropus* and *Sepedon aenescens*. Surveys should focus on numbers and densities of marsh flies in habitat adjacent to sites where Newcomb's snails are known to occur.

2.3. Predation by other introduced species. Conduct surveys to estimate the threat of predation by other introduced, nonnative species. A variety of introduced vertebrate predators may be responsible for reducing Newcomb's snail populations, however the level of threat posed by these species is not clear. Investigations should be directed towards threat assessments of the green swordtail (*Xyphophorus helleri*), the mosquito fish (*Gambusia affinis*), livebearing guppies (*Poecilia* spp.), the marine toad (*Bufo marinus*), the American bullfrog (*Rana catesbiana*), and the wrinkled frog (*Rana rugosa*).

2.4. Interaction with other introduced species.

2.4.1. Competition with introduced lymnaeid and physid snails. Competition with introduced lymnaeid and physid snails for space, food and other resources may detrimentally affect Newcomb's snail populations. The potential for negative interspecific interaction should be evaluated by surveying the occurrence, population distribution, and overlapping habitat requirements of introduced aquatic snails that co-occur with Newcomb's snail.

2.4.2. Evaluate *Bufo marinus* aquatic toxicity. The introduced toad *Bufo marinus* is found throughout lowland and mid-elevation areas of the Hawaiian Islands, including Kaua`i. These toads breed by congregating and laying large masses consisting of thousands of eggs in slow, deep pools such as the pools below terminal waterfalls where

Newcomb's snails are found (for example, the waterfall/pool complex in Kalalau Stream). This toad excretes highly toxic compounds from glands located in its skin. Recently, *Bufo marinus* has been implicated in creating conditions of acute and chronic aquatic toxicity due to its breeding activities in aquatic environments. The occurrence and distribution of *Bufo marinus*, and its potential to create toxic conditions in areas where it co-occurs with Newcomb's snail, should be investigated.

2.5. Predator and introduced species control. If predation or other interactions with introduced species is found to limit or reduce Newcomb's snail populations, develop and implement appropriate predator control measures, in coordination with other efforts to control introduced species in terrestrial and aquatic environments on Kaua`i and other parts of the State.

3. Maintain stream and spring flows to protect Newcomb's snail habitat.

3.1. Inventory of water diversion and water extraction activities. Inventory all existing and planned water diversion activities, including operation of wells and hydropower development proposals, that may impact known and potential Newcomb's snail habitat.

3.2. Instream flow standards development. Cooperate in the Water Commission's ongoing Stream Protection Program by providing technical assistance and review of the Commission's efforts to set quantifiable interim and permanent instream flow standards in watersheds that provide or potentially provide habitat for Newcomb's snail.

3.3. State Water Plan participation and coordination. Provide input into revision of the State Water Plan being prepared by the Water Commission with regard to water resource protection in watersheds that provide or potentially provide habitat for

Newcomb's snail. As specified in the State Water Code, this comprehensive planning effort is coordinated by the Water Commission with involvement from several State and county agencies. This involvement would be repeated approximately every 5 years.

3.3.1. State Water Projects Plan. Provide input into revision of the State Water Projects Plan being prepared by the Water Commission with regard to water resource protection in watersheds that provide or potentially provide habitat for Newcomb's snail.

3.3.2. Agricultural Water Use and Development Plan. Provide input into revision of the Agricultural Water Use and Development Plan being prepared by the Hawai`i State Department of Agriculture with regard to water resource extraction in watersheds that provide or potentially provide habitat for Newcomb's snail.

3.3.3. State Water Quality Plan. Provide input into revision of the State Water Quality Plan being prepared by the Hawai`i State Department of Health with regard to water resource protection in watersheds that provide or potentially provide habitat for Newcomb's snail.

**3.3.4. County of Kaua`i Water Use and Development Plan.** Provide input into revision of the County of Kaua`i Water Use and Development Plan with regard to water resource protection in watersheds that provide or potentially provide habitat for Newcomb's snail.

**3.4. County of Kaua`i General Plan.** Provide input into revision of the County of Kaua`i General Plan for agricultural and domestic purposes, with regard to water resource protection in watersheds that provide or potentially provide habitat for Newcomb's snail. This involvement would be repeated approximately every 5 years.

4. Conduct landscape planning and conservation efforts. A variety of landscape planning and conservation efforts are underway that may affect long-term management of land and water resources in watersheds that provide or may provide habitat for the Newcomb's snail.

4.1. Proposed Makaleha Natural Area Reserve. A portion of the Makaleha Watershed is being proposed for inclusion in the State of Hawai`i Department of Land and Natural Resources Natural Area Reserve System. Within the proposed area are the two known subpopulations of Newcomb's snail found in the Makaleha Stream watershed. This proposal to include an area containing Newcomb's snails in the Reserve System should be supported through cooperative efforts.

4.2. Hanalei American Heritage River Program. The American Heritage River Program facilitates cooperative participation by Federal, State, local, and non-government organizations in watershed planning, conservation, and development. In 1998, the Hanalei River was selected for participation as 1 of 14 rivers in the American Heritage River Program. Because the Hanalei River and its tributaries harbor four known subpopulations of Newcomb's snails, the Heritage River Program should, with substantial cooperation from us, take into account watershed preservation and water resource protection for recovery efforts benefitting the Newcomb's snail.

4.3. Partners for Fish and Wildlife Programs (private lands). Two populations of Newcomb's snail are located on private lands. A variety of cooperative projects under the Partners for Fish and Wildlife Program should be considered between us and the landowners to aid in recovery of the Newcomb's snail.

4.3.1. Lumaha`i Ahupua`a - Kamehameha Schools. The Lumaha`i River population of Newcomb's snail is located on lands within an ahupua`a (watershed-based land

division system derived from ancient Hawaiian land tenure). The entire Lumaha`i Ahupua`a is owned by Kamehameha Schools, previously known as the Bishop Estate, a very large private trust that owns approximately 10 percent the entire land area of the State of Hawai`I. The Lumaha`i Ahupua`a is managed to provide resources to operate a small private school for children of Hawaiian descent. A significant portion of the trust's lands are in the State Conservation District, and trust staff are developing proficiency in managing lands and water resources for the purpose of achieving a variety of conservation goals. Because the entire Lumaha`i watershed is owned by Kamehameha Schools, a unique opportunity exists to initiate comprehensive planning of land and water resources for conservation purposes. In the years 1999 through 2000, the Partners for Fish and Wildlife Program cooperatively developed a management framework for conservation activities in the Lumaha`i watershed. Expanded support of recommended conservation actions, including recovery activities for Newcomb's snail, should be undertaken by us in cooperation with Kamehameha Schools.

**4.3.2. Cornerstone Hawai`i Holdings LCC - Kealia Stream.** The Waipahe`e tributary of Kelalia Stream is located on land owned by Cornerstone Hawai`i Holdings, LCC. This land ownership and management company is currently involved in a variety of activities that include residential development, a variety of agriculture enterprises including agro-forestry and ranching, resort development, and tourism. A resource conservation plan for agricultural uses of the land is being prepared by the Natural Resources Conservation Service for the landowner. The landowner has solicited input from a variety of State and Federal agencies on management activities on their lands. We should ensure that comprehensive planning of land and

water resources for the conservation of Newcomb's snail is considered in the plan prepared by the Natural Resources Conservation Service. A Partners for Fish and Wildlife project to assist with protection of stream or watershed resources should be developed with the landowner.

5. Develop and implement a public outreach program for Newcomb's snail. Public outreach on the preservation of inland surface water and groundwater resources and the habitat that these waters support is important as Kaua`i undergoes changes in its agricultural economy and growth in urban land use. As residents of Kaua`i and the rest of the State become more aware of these issues, they might be more receptive to conservation of the Newcomb's snail. Visitor centers at State Parks, U.S. Fish and Wildlife Service refuges, and other State, Federal, and non-governmental facilities can be contacted to provide exhibit space, and to develop printed and multi-media material to provide opportunities for people to understand this unique organism.

Table 2. Cross-reference of recovery actions and listing factors for the Newcomb's snail.

Listing Factor	Threat	Still a Threat?	Recovery Actions	Recovery Criteria
A - Present or threatened destruction, modification, or curtailment of habitat or range.	Modification of stream and spring flows.	Yes	1.1, 1.2, 1.3, 1.4, 1.5, 1.6.1, 3.1, 3.2, 3.3.1, 3.3.2, 3.3.3, 3.3.4, 3.4, 4.1, 4.2, 4.3.1, 4.3.2, 5	1, 2, 3, 5
B - Overutilization for commercial, recreational, scientific, or educational purposes.	Not Applicable.			
C - Disease or predation.	Predation and competition from non-native species.	Yes	1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 2.4.1, 2.4.2, 2.5, 4.1, 4.2, 4.3.1, 4.3.2, 5	1, 2, 4, 5
D - Inadequacy of existing regulatory mechanisms.	Not Applicable.			
E - Other natural or manmade factors.	Not Applicable.			

IV. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated costs for the recovery of the Newcomb's snail. It is a guide for meeting the objectives discussed in Chapter II of this plan. This schedule indicates action priority, action numbers, action descriptions, duration of actions, the organizations involved and responsible for committing funds, and estimated costs. When more than one organization is listed as the responsible party, an asterisk is used to identify the lead entity.

The actions identified in the implementation schedule, when accomplished, should lead to a better understanding of the current distribution and status of Newcomb's snail, protect habitat for the species, stabilize the existing populations, and allow for an increase in population sizes and numbers.

A. Recovery Action Priorities

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 2: An action that must be taken to prevent a significant decline in species population or habitat quality, or to prevent some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

B. Acronym Definitions

ES	U.S. Fish and Wildlife Service, Ecological Services, Pacific Islands Ecoregion, Honolulu, Hawai`i
HHR	Hanalei American Heritage River Program
HIDOA	Hawai`i Department of Agriculture
HIDOH	Hawai`i Department of Health

COWRM	Commission on Water Resources Management, Hawai`i Department of Land and Natural Resources
COK	County of Kaua`i
DAR	Division of Aquatic Resources, Hawai`i Department of Land and Natural Resources
DOFAW	Division of Forestry and Wildlife, Hawai`i Department of Land and Natural Resources
WRD	United States Geological Survey, Water Resources Division
C	Actions that will be implemented on a continual basis once begun.

Implementation Schedule for the Newcomb's snail Recovery Plan.

Priority #	Action #	Action Description	Action Duration	Responsible Party (*lead agency)	Total Cost - FY 2017	Costs Estimates ($1,000's)													
						FY 04	FY 05	FY 06	FY 07	FY 08	FY09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Conduct research essential to the conservation of the species.																			
1	1.1	Survey and monitoring protocol development.	2	ES * DAR	**30** **20**	15 10	15 10												
1	1.2	Implementation of monitoring program.	C	ES* DAR	**40** **40**		5 5	5 5	5 5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5	2.5 2.5
1	1.3	Obtain basic life history information.	14	ES* DAR	**34** **16**	5 2	5 2	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1
1	1.4	Survey potential and historical habitat.	14	ES* DAR	**14** **3**	1 1	1 1	1 1	1	1	1	1	1	1	1	1	1	1	1
1	1.5	Initiate translocation program.	C	ES* DAR UH	**128** **31** **90**			50 10 40	50 10 40	10 2 10	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1	2 1
Subtotal					**446**	**34**	**44**	**115**	**114**	**31**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**	**12**
Manage predation and interspecific interaction.																			
1	2.1	Predation by *Euglandina rosea*.	3	ES* DAR UH	**15** **15** **25**	5 5 15	5 5 5	5 5 5											
1	2.2	Predation by *Sepedomerus macropus* and *Sepedon aenescens*.	3	ES* DAR UH	**15** **15** **25**	5 5 15	5 5 5	5 5 5											
1	2.3	Predation by other introduced species.	3	ES* DAR UH	**15** **15** **25**	5 5 15	5 5 5	5 5 5											

Priority #	Action #	Action Description	Action Duration	Responsible Party (*lead agency)	Total Cost - FY 2017	Costs Estimates ($1,000's)													
						FY 04	FY 05	FY 06	FY 07	FY 08	FY09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
1	2.4.1	Competition with introduced lymneid and physid snails.	3	ES DAR UH*	**15** **15** **25**	5 5 15	5 5 5	5 5 5											
1	2.4.2	Evaluate *Bufo marinus* aquatic toxicity.	3	ES DAR UH*	**15** **15** **25**	5 5 15	5 5 5	5 5 5											
1	2.5	Predator and introduced species control.	C	ES* DAR	**400** **200**			100 50	100 50	20 10	20 10	20 10	20 10	20 10	20 10	20 10	20 10	20 10	20 10
Subtotal					**875**	**125**	**75**	**225**	**150**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**
Maintain stream and spring flows to protect Newcomb's snail habitat.																			
2	3.1	Inventory of water diversion and water extraction activities.	2	ES* DAR	**15** **15**	5 5	5 5	5 5											
2	3.2	Provide input into Instream Flow Standards development.	C	COWRM* ES	**340** **75**	20	50 10	50 10	20 5	20 5	20 5	20 5	20 5	20 5	20 5	20 5	20 5	20 5	20 5
2	3.3.1	Provide input into State Water Projects Plan.	C	COWRM* ES	**70** **5**		10 1	20 1					10 1	20 1					10 1
2	3.3.2	Provide input into Agricultural Water Use and Development Plan.	C	HIDOA* ES	**70** **5**		10 1	20 1					10 1	20 1					10 1
2	3.3.3	Provide input into State Water Quality Plan.	C	HIDOH* ES	**70** **5**		10 1	20 1					10 1	20 1					10 1

Priority #	Action #	Action Description	Action Duration	Responsible Party (*lead agency)	Total Cost - FY 2017	Costs Estimates ($1,000's)													
						FY 04	FY 05	FY 06	FY 07	FY 08	FY09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
2	3.3.4	Provide input into County of Kaua`i Water Use and Development Plan.	C	CoK* ES	**70** **5**		10 1	20 1					10 1	20 1					10 1
3	3.4	Provide input into County of Kaua`i General Plan.	C	CoK* ES	**40** **4**			10 1	10 1					10 1	10 1				
Subtotal					**789**	**30**	**114**	**165**	**36**	**25**	**25**	**25**	**69**	**120**	**36**	**25**	**25**	**25**	**69**
Conduct landscape planning and conservation efforts.																			
3	4.1	Proposed Makaleha Natural Area Reserve.	C	DOFAW* ES	**110** **7**	20 2	30 5	5	5	5	5	5	5	5	5	5	5	5	5
3	4.2	Hanalei American Heritage River Program.	C	HHR* ES	**50** **20**	5 5	5 5	5 5	5 5	3	3	3	3	3	3	3	3	3	3
3	4.3.1	Lumaha`i Ahupua`a - Kamehameha Schools.	C	KS* ES	**85** **30**	10 10	10 10	10 10	5	5	5	5	5	5	5	5	5	5	5
3	4.3.2	Cornerstone Hawai`i Holdings LCC - Kealia Stream.	3	CHH* ES NRCS	**15** **15** **15**	5 5 5	5 5 5	5 5 5											
Subtotal					**347**	**67**	**80**	**50**	**20**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**
Develop and initiate a public outreach program for Newcomb's snail.																			
3	5	Develop a public outreach program for Newcomb's snail.	C	ES	**33**	15	5	2	1	1	1	1	1	1	1	1	1	1	1
Subtotal					**33**	**15**	**5**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

Priority #	Action #	Action Description	Action Duration	Responsible Party (*lead agency)	Total Cost - FY 2017	Costs Estimates ($1,000's)													
						FY 04	FY 05	FY 06	FY 07	FY 08	FY09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Validate recovery objectives.																			
3	1.6.1	Determine number of populations and individuals needed for long-term recovery and survival.	5	ES	**25**	5	5	5	5	5									
3	1.6.2	Revise de-listing criteria as necessary.	3	ES	**15**												5	5	5
Subtotal					**40**	**5**	**5**	**5**	**5**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**5**	**5**
TOTAL COST					**2,530**	**276**	**323**	**562**	**326**	**105**	**81**	**81**	**125**	**176**	**92**	**81**	**86**	**86**	**130**

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